SOFT X-RAY L-SPECTRA OF Fe, Co, Ni, Cu AND THEIR OXIDES*

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ABSTRACT. $L_{2,3}$ band spectra of Fe—Cu and their oxides have been investigated in the region 13—18 A. U. with bent mica and gypsum crystal in a Siegbahn's vacuum grating spectrograph. L_3 bands of Fe—Ni have more or less the same energy width of 13—16 eV. In these elements a weak extended structure on the short wavelength side of the main $L\alpha$ band has been observed. The main $L\alpha$ band having a width of 5eV approximatelv, along with its extended structure on the shorter wavelength side has been considered to be the valence bands of these elements.

INTRODUCTION

The valence bands of the elements iron, cobalt, nickel and copper consist of overlapped $3d$; $4s$, p bands. $L_{2,3}$ valence band spectra of these elements reflect the energy spectra of $3d$, $4s$ electrons. The wavelength range of $L_{2,3}$ radiations lie between 13—18 Å. and is too short compared to their M spectral region. Thus there will be some broadening of the edges due to the radiation damping in the case of the $L_{2,3}$ valence band spectra ; while in the case of M spectra, due presumably to the Auger broadening of the X-ray levels, the valence band will have some broadening effect. Moreover, M_2 and M_3 bands might overlap quite considerably creating complications in the point of analysis, while in the $L_{2,3}$ region of these elements, the L_2 and L_3 bands are distinctly seperated from each other.

The L bands of metals Fe-Ge were investigated by Gwinner (1938) using a bent crystal spectrometer.

The present investigation was undertaken to obtain, $L_{2,3}$ bands of Fe-Cu in pure elements and in their oxides. In the case of copper oxide, special attention was given to investigate the difference in the band pattern of cuprous oxide from that of cupric oxide. Special care was taken to keep the metal surface of the target of the X-ray tube free from oxidation when studying the pure elements.

EXPERIMENTAL RESULTS

$L_{2,3}$ bands of Fe, Co, Ni and their oxides have been investigated with a bent mica crystal in a Siegbahn's vacuum grating spectrograph. For the investigation of $L_{2,3}$ bands of copper and its oxides, a bent gypsum crystal was used. Fine platinum wire coated with suitable oxides was used as a

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rated from the L_a band. The peak position of the L_a band is at 15,930 X.U. There is a sign of a distinct short wavelength structure at 15,906 X.U. This structure appears prominently in Co-Cu alloys.

Nickel.—The width of the L_3 band of nickel is 15.8 eV. The peak at 14,530 X.U., lies towards the low energy side of the band. The extension on the shorter wavelength side of the main peak is quite prominent. In the case of nickel oxide, the total band width of L_a band is nearly of the same width as that in pure Nickel. The prominent structure at 14,423 X.U. in the case of nickel oxide is clearly noticeable unlike the oxides of iron and cobalt.

Copper.—L_a or L_3 band of electrolytic copper is a broad band having a width of about 19.0 eV with three distinct structures in the L_3 band at 13,325, 13,267 and 13,205 X.U. In CuO, the band pattern changes considerably, as shown in the microphotometer records. In Cu_2O, there is a prominent long wavelength tailing not to be found in CuO or Cu.

CONCLUSION

The investigation of L_a bands of Fe-Cu and their oxides clearly points out the following facts:

(1) The valence bands, viz.: $3d$; $4s$, p bands, of all these elements consist of a broad band with structure.

(2) The widths of L_3 band of these elements are fairly of the same order (Table I).

TABLE I

Widths of L_3 of band in eV								
Fe	Fe_3O_4	Co	CoO	Ni	NiO	Cu	Cu_2O	CuO
13.2	13.0	13.7	...	15.8	17.0	19.0	24.0	19.0

(3) The change in the band pattern of L_3 band in the case of oxides points out a change in the distribution of electron density in the valence band. The cross-transition effect will also be responsible for the difference in L_3 band pattern. Electrons behaving as oxygen $2p$ can easily fill up the L_3 vacancy of the metal ion, in which case, the selection principle is not disobeyed.

(4) The most prominent structure of L_3 band of these elements on the low energy side, usually referred to as L_a, possibly represents $3d$ electrons, which shifts towards the shorter wavelength side in the case of oxides. In the case of Mg, Al, Si oxides, the shift of the valence band of the metal ion is towards the longer wavelength side.

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